IFERP
ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 9, Issue 6, June 2022

Effect of Coconut Husk Layer on the Behavior of Industrial Helmet

[1] Yogesh Shivhare, [2] Manoj Narwariya*, [3] Chaitanya Sharma, [4] Vijay Verma, [5] Arun Pandey

[1] [2] IPS College of Technology and Management, Gwalior, Madhya Pradesh, India.
[3] BIT Sindhri, Dhanbad, Jharkhand, India.
[4] [5] Bundelkhand Institute of Engineering and Technology, Jhansi, Uttar Pradesh, India.
Corresponding Author Email: [2] *manoj.narwariya@gmail.com

Abstract— ***All helmets are designed to prevent head injury of wearer by captivatingmomentum and preventing infiltration. Aside from the ability to absorb energy, their volume and weight are also essential considerations, as increase in both will increase the danger of damage to the user's body parts. Annually, several construction laborswere killed or critically incapacitateddue to head traumas. Appropriate helmet not only decreases the chances of serious damage but also reduces loss of life. This study focuses on increasing the strength of an industrial helmet. This is carried out altering material system and its combinations and analyzing the improved helmet.The helmet was designed in Solid Works, and the analysis was done with the commercial software Ansys. The total deformation, stress distribution, and total strain were used as performance indicators.***

Keywords: Industrial helmet, Coconut husk, Ansys analysis, Nylon.

I. INTRODUCTION

Helmet ashielding headgear that is used to protect skull from harms. Ritual or emblematic helmets with no protective use (i.ean helmet used by English cop's) are occasionally worn. Assyrian troops around 900BC wore heavy dead animal skin or bronze helmets to safeguard their heads from dullarticle and weapon hits, as well as arrow strikes. Soldiers continue to wear helmets, which are now frequently made of lightweight plastic, and of composite materials.

Helmets are used in civilian life for entertainment and amusement events and sports (such as climbing, skating, ice skating etc.); peoples working in risky places (such as building infrastructure, and rebellion police). Helmets are also used while riding motorcycles and bicycles. Since the 1990s, the majority of helmets have been made of thermosets polymers, which may be filled with aramid fibres.

In high-energy collisions, the assembly and shielding capabilities are altered. Aside from their ability to absorb energy, their volume and weight are also essential considerations, as increased size and weight increase the danger of hurt to user's head and neck and makes wearing helmet highly uncomfortable. Neurosurgeons invented anatomical helmets fitted to the inner skull structure at the end of the twentieth century.

Helmets come in a variety of stylesfor various uses. A bicycle helmet, for example, have a main purpose to safeguard the head of rider from impact force caused by collision of head with road. Rock climbing helmet must protect against severe impact as well as anything falling from above, such as small boulders and climbing equipment. Helmet design is also dictated by practical considerations: maintaining aerodynamics and ventilation are main objectives of helmet used by bikers whereas low inertia and compact to avoid interfering with climbing without compromising with its capability to protect are main aim of climbers helmet.

Protecting head is not an only requirement of helmet, some attachment were also used to increase the safety of wearer. Such as a jaw cage for cricket, a face shield for person working with welding, air tight chamber with oxygen supply for peoples working in chemical environment [1].

Branditet. al. identify the usefulness of helmet in monetary term and come up with conclusion that about $6000 can be saved from hospital expenses during injuries only by wearing helmet [2]. Ginsberg and Silverberg in their detail study of accidents in and around Israel, suggest that just be wearing helmet can save 57 lives and $60-70 million total benefits from reduced need of hospitals and decrease in absenteeism rate [3].

Fernandes et al. conducted a comprehensive evaluation of different types of helmets and their efficiency in reducing harm, concluding that non penetrating head injuries can be induced by short duration acceleration acting on the head.Several other researchers come up with different modifications to extend the life and usability of helmet. Most of their studies were concentrated on the motorcycle helmet as number of accidents and causalities are more. In other side the industrial employees which are the workforce to build the nation was left with less or very few modification studies were conducted on industrial helmet [4]. More recently Mahadi propose the use of palm fruit cell fibre for increasing the strength and decreasing the weight of helmet [5]. Verma et. al. in their work suggests the effect of particle morphology on the behaviour of polymer composite and suggest that spherical shape of particulate reinforcement is always better compared to rod shape long reinforcement [6-11]. Various types of fiber fillers is used for reinforcing industrial helmet such as banana fiber, coir fiber ad glass fiber [12-14]. Small size coir fibres improve tensile strength of coir glass fibre composites facilitates owing to absence of eliminate curling, and better fibre matrix bonding. Further, increase in numbers of glass fibre layers (up to 3 layers) found to enhance tensile and flexural strength of composites [15].

Simulation is becoming important day by day as it offers many advantages and is versatile and economic. It can be applied to any material or component easily and provide reliable results promptly at reasonable cost. For example, heat flow behaviour within and around a brake disk during brake testing was analysed on the model developed by CATIA V5, using finite element analysis (FEA) with the help of ANSYS 19, designing of optimal component for EcoKart[16, 17]. Therefore, present paper aims to use Solidworks/Ansys to analyze the effect of natural coconut husk layer in improving the structural stability and safety of industrial helmet. Beside improving the safety rating of industrial helmet coconut husk layer also reduces heat pileup on head and sweating as a result of prolong uses of industrial helmet.

II. METHODOLOGY

The geometrical modelling was done in Solidworks with the dimension and other properties as shown in table 1. Figure 1 shows the geometric model of helmet.

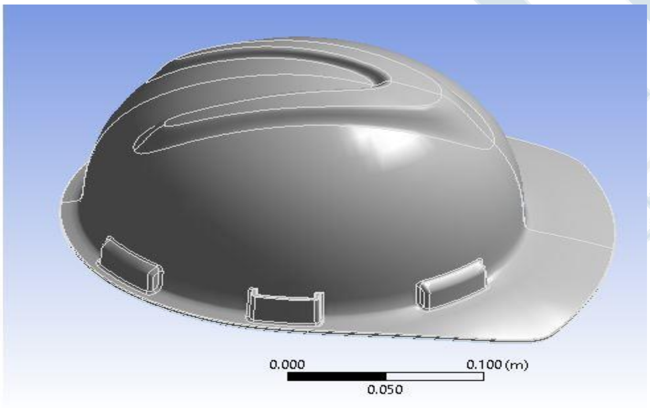

Fig.1 Geometric model of Industrial Helmet used for analysis.

Table 1. Geometric parameters and properties of helmet used for analysis.

Bounding Box		
Length X	209.99 mm	208.36 mm
Length Y	283.29 mm	281.64 mm
Length Z	157.89 mm	151.96 mm
Properties		
Volume	2.3994e+005 mm³	1.9662e+005 mm³
Mass	0.33592 kg	0.27527 kg
Centroid X	-9.9101e-004 mm	-0.1107 mm
Centroid Y	161.91 mm	154.71 mm
Centroid Z	36.423 mm	18.791 mm
Moment of Inertia Ip1	2600.9 kg·mm²	1984.8 kg·mm²
Moment of Inertia Ip2	1764.3 kg·mm²	1456.5 kg·mm²
Moment of Inertia Ip3	2693.2 kg·mm²	2463.8 kg·mm²

For comparison both with and without coconut husk layer model was taken for analysis in Ansys. The structural analysis was done with a presumed load of 50 N. The deformations and stress was recorded as output for comparison. The outer layer of helmet was taken of conventional nylon 4-6 and inner layer is made of coconut husk. Table 2 details the mechanical properties of both the material used in the present work [18]. Figure 2 shows the mesh convergence graph thus element size is chosen based on the above analysis and were constant throughout.

Table 2 Shows the mechanical properties used in the analysis

Property	Nylon 4-6	Coconut husk
Young's modulus (MPa)	889.09	5000
Bulk modulus (MPa)	1397.9	4166.7
Shear modulus	318.9	1923.1
Poisson's ratio	0.394	0.3
Density (kg/m3)	1.4e-006 kg mm^-3	1.288e-006

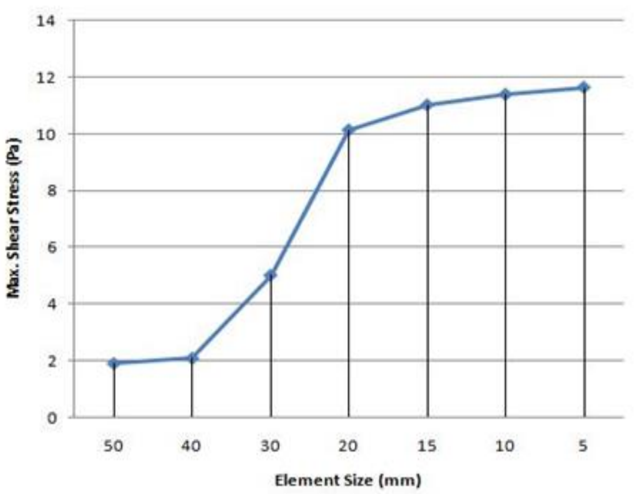

Fig. 2 shows the mesh Convergence graph

IFERP
ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 9, Issue 6, June 2022

III. RESULTS AND DISCUSSION

The static structural analysis was performed on the helmet by application of 50N load and then total deformation, maximum shear stress and maximum shear strain were analysed. Out of the other type of impact on which the human bearing the helmet can control. The most important and unusual impact is vertical drop of load which is unpredictable and un-know. This vertical drop load caused maximum injury and may result in life loss to. In the present case the vertical top drop was considered for analysis.

Case 1: Plane Nylon helmet

The geometry was imported from Solid Works and a load of 50N was applied as drop from vertical downward.

The analysis results were summarized and are tabulated in table 3.The maximum deformation is obtained at the point of application of load on the top of the crown strap and the minimum deformation is 0 due to the fixed support of the brim. The maximum shear stress and maximum shear strain are developed at points where the stress concentration is maximum due to design.

Case 2: Analysis of helmet with Coconut Husk

After obtaining the results of helmet with Nylon,we further added a 2 mm thick layer of coconut husk above the head band and equivalent shear stress, total deformation and equivalent shear strain were analysed with remaining condition as same.

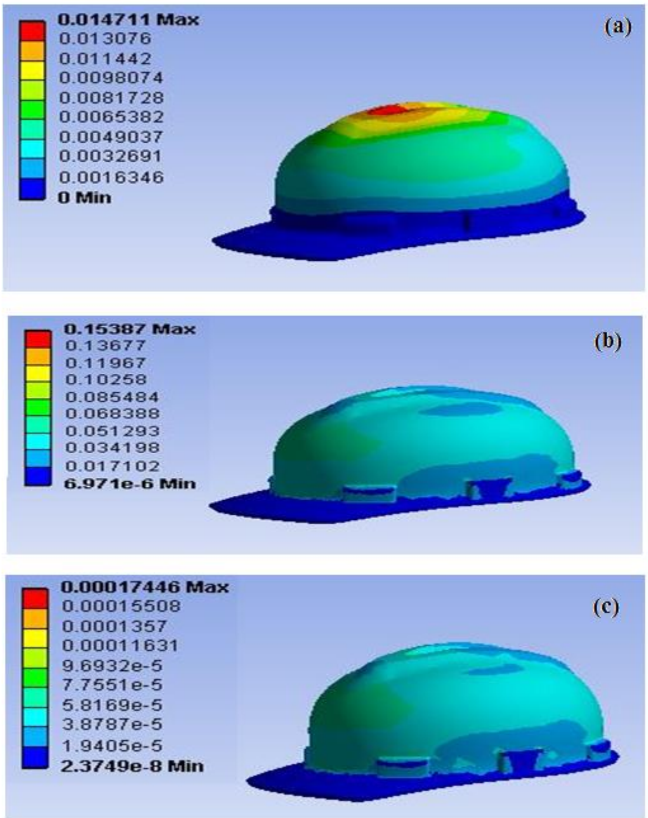

Fig. 3 Shows the behaviour of nylon helmet (a) Total deformation, (b) Equivalent stress, (c) Equivalent strain.

Table 3: Helmet with Nylon when force acts on the top portion

Load	Place	Max. Deformation (mm)	Max Equivalent Stress (MPa)	Min. Equivalent Stress (MPa)	Max. Equivalent Elastic Strain	Min. Equivalent Elastic Strain
50	Top	0.0147	0.1538	6.97e-6	1.74e-4	2.37e-8

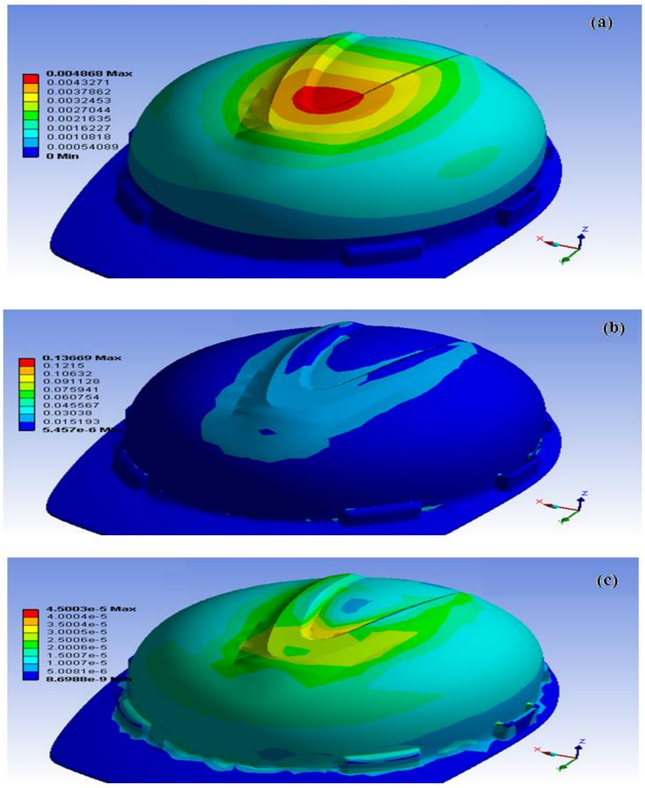

Fig. 4 shows the behaviour of nylon-coconut husk layer helmet (a) Total deformation, (b) Equivalent stress, (c) Equivalent strain.

Table 4: Helmet with coconut husk layer and force acts on the top portion

Load	Place	Max. Deformation (mm)	Max Equivalent Stress (MPa)	Min. Equivalent Stress (MPa)	Max. Equivalent Elastic Strain	Min. Equivalent Elastic Strain
50	Top	0.004868	0.13669	4.457e-6	4.500e-5	8.698e-9

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 9, Issue 6, June 2022

The maximum deformation is obtained at the point of application of load on the top of crown strap and the minimum deformation is 0 due to the fixed support of the brim. The maximum shear stress and maximum shear strain are developed at points where the stress concentration is maximum due to design.

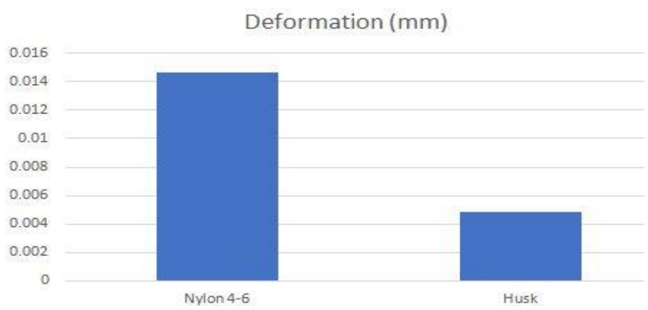

Fig.5 Represents total deformation with 50 N load.

Figure 5 shows the comparison between the displacement of nylon helmet and helmet with coconut layer with nylon.From figure we can see that the total deformation reduces considerably. Thus, become more safer for the industries.

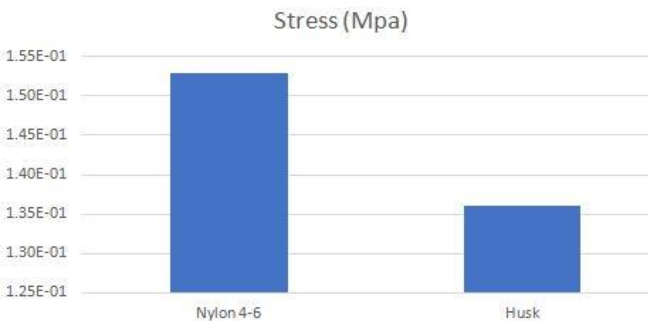

Fig. 6 Represent equivalent (von-mises) stress with 50 N load

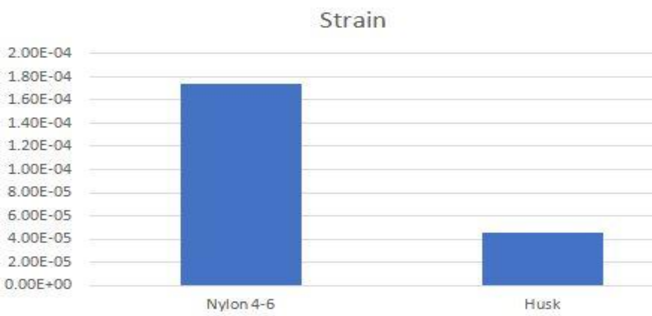

Fig. 7 Represent equivalent (von-mises) strain with 50 N load

Figure 5, 5 and 7 shows the comparison between the displacement, equivalent stress and strain of nylon helmet and helmet with coconut layer with nylon.From these figures we can see that the total deformation, equivalent stress and strain, respectively reduces considerably. Thus, the helmet with 2 mm thick layer of coconut husk becomes more safer for the industries.

Table 5: Summarized the value and improvement made by having a layer of coconut husk.

PROPERTIES	NYLON	COCONUT HUSK	IMPROVEMENT (%)
Max. deformation(mm)	0.0147	0.004868	66.8
Max. Shear Stress(MPa)	0.1538	0.13669	11.12
Max. Shear Strain(m/m)	1.74e-4	4.500e-5	74.13

IV. CONCLUSIONS

Analysis of industrial helmet was presented in the paper. The introduction of coconut husk layer in the helmet will enhanced the safety measures and sustainability of it. The addition of a coconut husk layer at the bottom of head band of industrial helmet will have a significant reduction in terms of total deformation, maximum shear stress and improvement in maximum shear strain.Based on analysis following were the main conclusions drawn out from the study:

- ✓ The total deformation gets reduced by 66.8 %
- ✓ The maximum shear stress gets reduced by 11.12 %
- ✓ The maximum shear strain is improved by 74.13 %

Thus in future if an industrial helmet is fabricated with a combination of coconut husk and nylon as the materials, the helmet will have better strength,lower deformation, more stress bearing ability,uniform pressure distribution. This will improve the safety features of industrial helmet.

REFERENCES

[1] Maiyuran C, Karthick R., Aravind S., Design and analysis of Industrial safety helmet using polyamide 4.6,IJARIIE, 2018,4-2, , pg-1395-1400.

[2] Bandrt M.M., Ahrns K.S., Corpron C.A., Franklin G.A., Wahl W.L., Hospital Cost Is Reduced by Motorcycle Helmet Use, The Journal of TRAUMA_ Injury, Infection, and Critical Care, 2002, 53-3, pg 469-471.

[3] Ginsberg G.M., and Silverberg D.S., A Cost-Benefit Analysis of Legislation for Bicycle Safety Helmets in Israel, American Journal of Public Health, 1994, 84-4, pg, 653-656

[4] Fernandes F.A.O., Alves de Sousa R.J., Motorcycle helmets—A state of the art review, Accident Analysis and Prevention, 2013, 56, pg-1– 21.

[5] Mahadi, Manufacture and impact analysis of bmx helmet made from polymeric foam composite strengthened by oil palm empty fruit bunch fiber, IOP Conf. Series: Materials Science and Engineering, 2018, 309, 012102.

[6] Shukla D.K., Sonia P. and Verma V, "Characterization of Fracture Properties of Epoxy-Alumina Polymer Nanocomposite", Applied Mechanics and Materials Vol. 390, pp 557-561, 2013.

[7] Verma V, Shukla D.K., Vineet Kumar, "Estimation of fatigue life of epoxy alumina polymer nanocomposites"; Procedia Materials Science 5, pp 669 – 678, 2014.

[8] Verma V, Sayyed AHM, Sharma C, Shukla DK., "Tensile and Fracture Properties of Epoxy Alumina Composite: Role of Particle size and Morphology", Journal of Polymer Research, 2020, 27 (388), doi.org/10.1007/s10965-020-02359-z, ISSN 1022-9760.

[9] Verma V, Sharma C, "Fatigue behaviour of epoxy alumina nanocomposite- Role of particle morphology", Theoretical and Applied Fracture Mechanics, 2020, 110, 102807, https://doi.org/10.1016/j.tafmec.2020.102807, ISSN 0167-8442.

[10] Verma V, Tiwari H, "Role of filler morphology on friction and dry sliding wear behavior of epoxy alumina nanocomposite", IMech: Part J Journal of Engineering Tribology, 2021, 235-8, 1614-1626, doi.org/10.1177/13506 50120970433, ISSN 1350-6501.

[11] Vijay Verma, Arun Kumar Pandey, Chaitanya Sharma. Fatigue Behaviour of Particulate Reinforced Polymer Composite - A review in Advanced Materials and Manufacturing Processes CRC press 2021, 155-172.

[12] Kim S., Lee J., Roh C., Eun J., Kang C., "Evaluation of carbon fiber and p-aramid composite for industrial helmet using simple cross-ply for protecting human heads", Mechanics of Materials, 209, 139, 103203,doi.org/10.1016/j.mechmat.2019 .103203.

[13] Singh Y., Singh J., Sharma S., Lam T D., Nguyen D. N., "Fabrication and characterization of coir/carbon-fiber reinforced epoxy based hybrid composite for helmet shells and sports-good applications: influence of fiber surface modifications on the mechanical, thermal and morphological properties", Journal of Materials Research and Technology,2020, 9(6), 15593-15603,doi.org/10.1016/ j.jmrt.2020.11.023.

[14] Prajapait P, Sharma C,Shrivastav R, Rana RS. "Evaluation of mechanical proper-ties of coir and glass fiber hybrid composites. Materials Today: Proceedings, 2018, 5,19044-19050

[15] Camelia PB, Bhandari R, Sharma C,Dhakad SK, Cosmin P, Sharma AK, An investigation of thermal behaviour of brake disk pad assembly with Ansys, Materials Today: Proceedings, 2021, 47, 2322-2328

[16] Sharma C,Kumar R, Dutt T, Kumar S, Shrivastava A. Design and Fabrication of Environment Friendly Kart. International Journal of Engineering Research and Applications, 2014, Special Issue, 338-342,

[17] Ravi Y.V., KapilanN., RajoleS., BalajiY.S, Reddy V.K., VenkateshaB.K.,Damage resistance evaluation of E-glass and hybrid hemp-banana natural fiber composite helmet using drop weight impact test", 2021, Materials Today: Proceedings,doi.org/10.1016/j.matpr.2021.09.213.

[18] Obele1 C., Ishidi E., "Mechanical Properties of Coir Fiber Reinforced Epoxy Resin Composites for Helmet Shell", Industrial Engineering Letter, 2015, 5 (7), 67-75.